Reliable Renewable Energy Challenges

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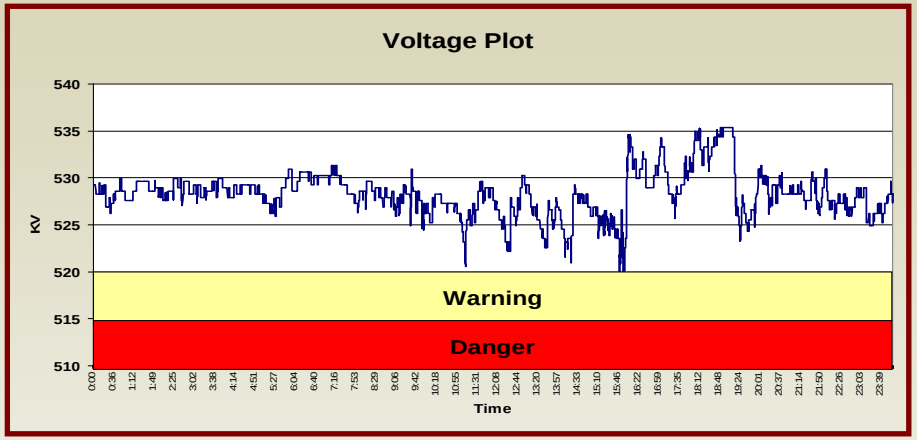
Grid Operations and Market Operations Key Roles

- Day Ahead Energy Market Operation
- Real-time Imbalance Energy Market
- Scheduling of Power Import/Exports
- Transmission Congestion Management
- Grid Planning
- Real-Time Energy Dispatch
- Voltage control of the grid
- Outage scheduling - Transmission & Generation
- Integration of Renewable Resources
  - Forecasting of wind & solar generation
  - Ramp planning
  - Frequency control & regulation of system imbalance energy
  - Operating reserves & replacement energy

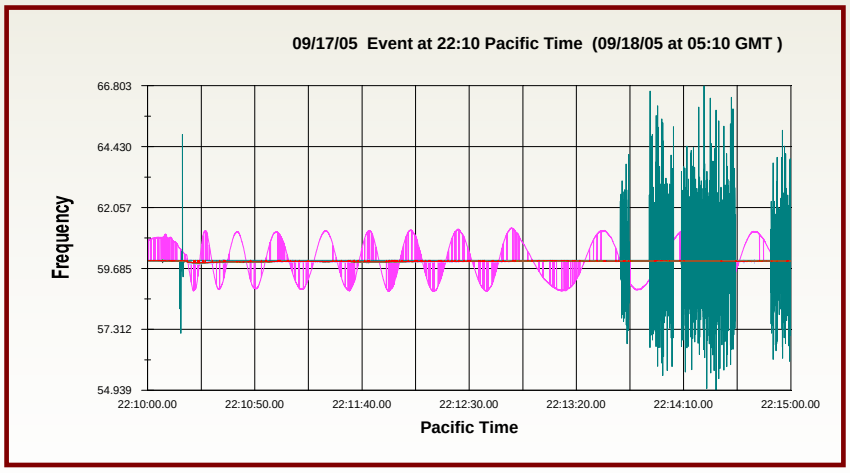
Ensure reliable operation of the grid: "keep the lights on"

CAISO - Key Grid Operations Metrics

Thermal Limits & Veg. Mgmt of ROW



Voltage Stability Limits



Transient Stability Limits

NERC
NORTH AMERICAN ELECTRIC RELIABILITY CORPORATION

Sets Standards for Grid Operators & Grid Planners

- 118 Standards
- 539+ Requirements

Failure to meet any of these standards can result in major fines and penalties

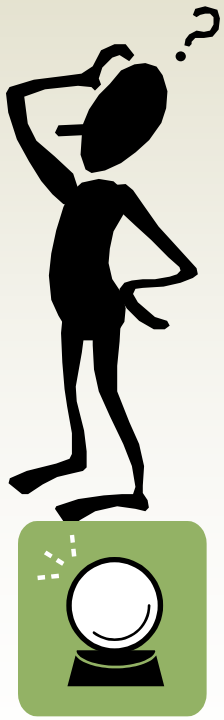
Key Renewables Integration Questions

Where are the best renewable resources areas?

Is there transmission in the area? What upgrades are required?

Who Pays for transmission upgrades? $$

What type of renewables? Wind, Solar, Geothermal, Biomass, Tidal, Hydro

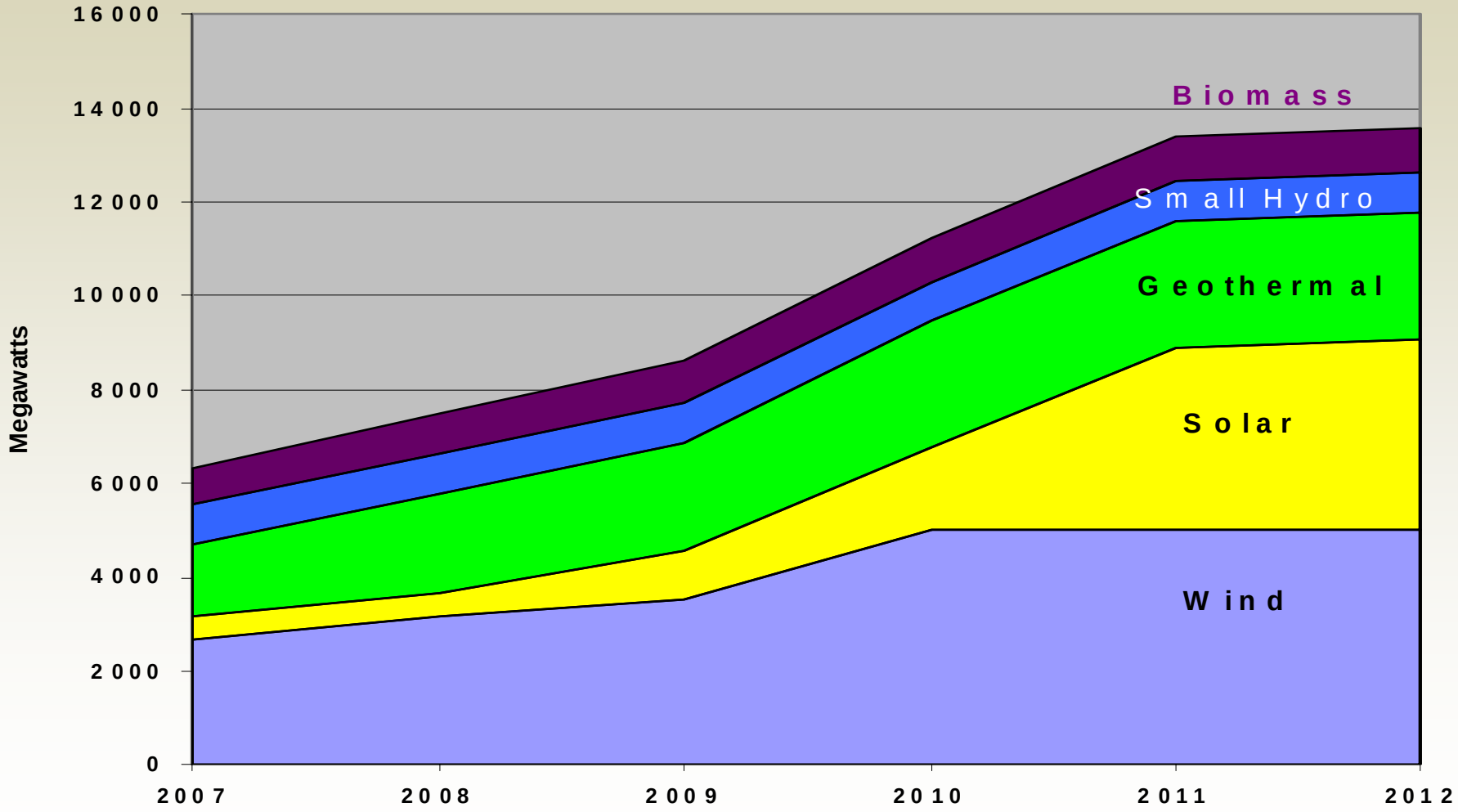


What is the impact on Grid Operations and Reliability?

What is the cost of the energy?

Can we forecast and schedule the energy production?

Renewable Resources - Nameplate Rating



Integration of Renewables Issues

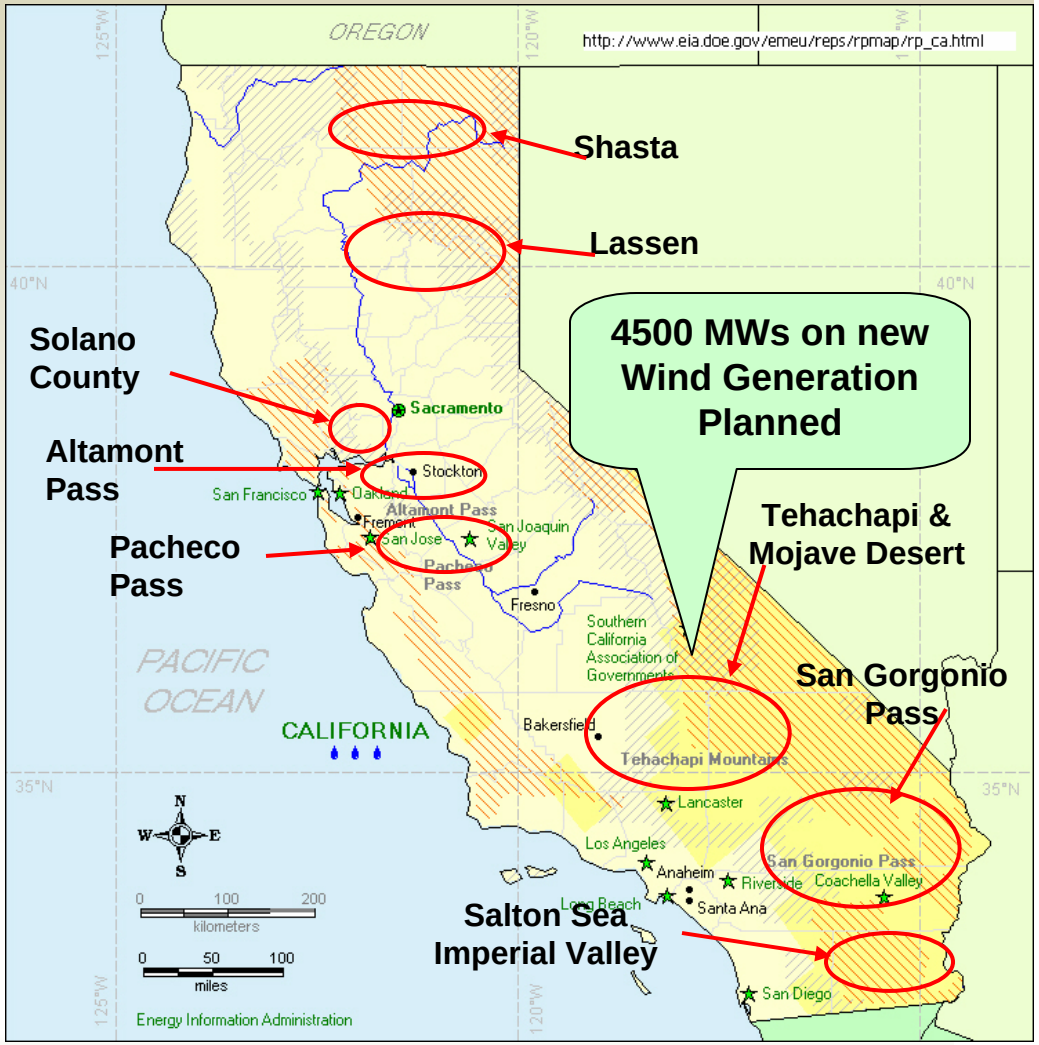
- Sitting and permitting of renewable resources
- Approval of a transmission plan
- Building of transmission facilities
- Additional resources for reliable operation
  - Forecasting of renewables energy production
  - Replacement generation
  - Regulation and ramping resources
  - Energy Storage facilities
  - Demand response programs

The Transmission system study included both existing and new wind generator installations

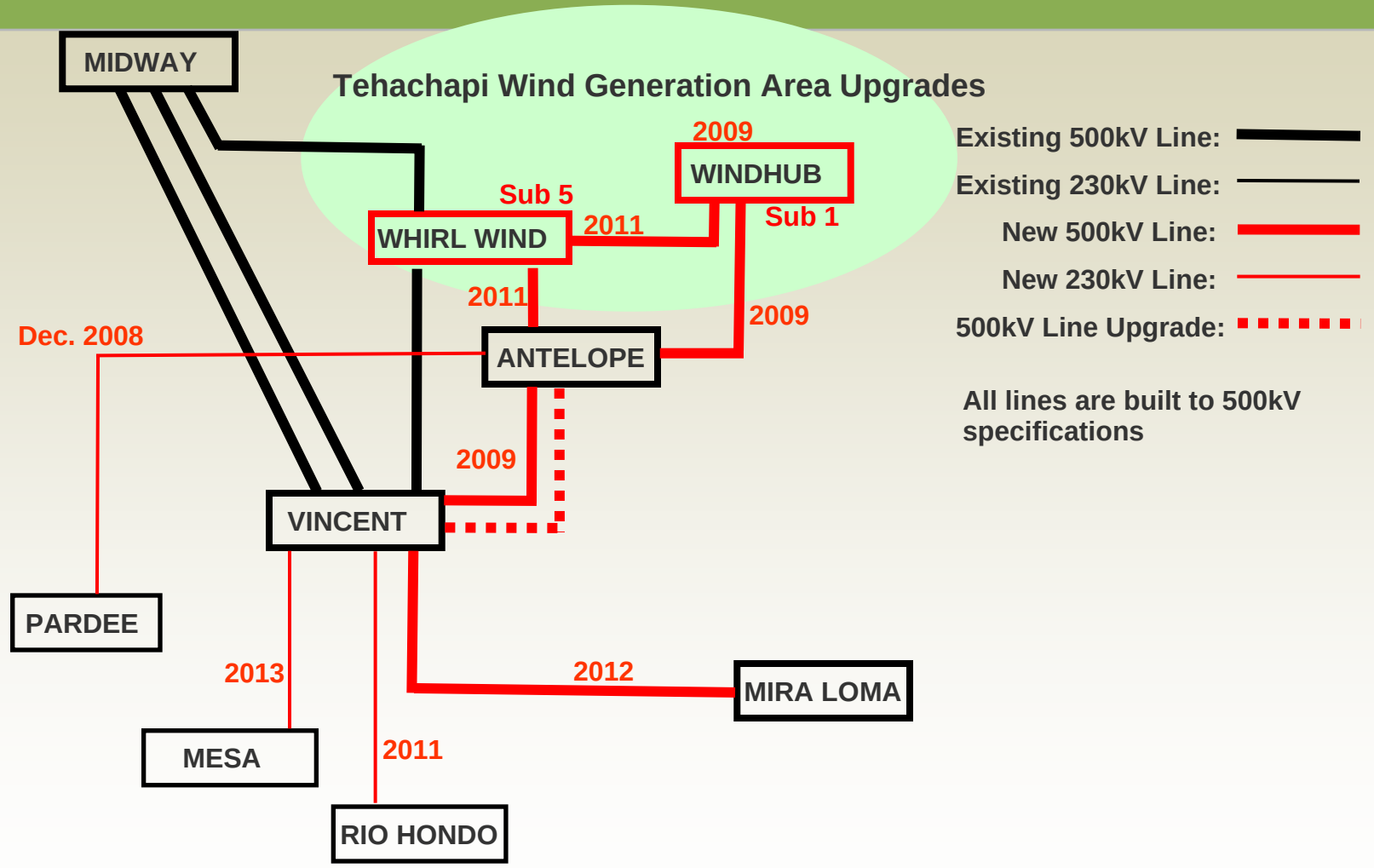
The CAISO study assumes the new wind generation (4500 MW) is installed in the Solano and Tehachapi wind areas based on projects in the transmission queue and approved transmission upgrades.

The CAISO study accounts for

- 2,600 MW of **existing** wind generation plus the addition of
- 4,500 MW of new wind generation for a total of
- 7,100 MW wind generation by the year 2012.



Study assumes Tehachapi transmission upgrades built on schedule



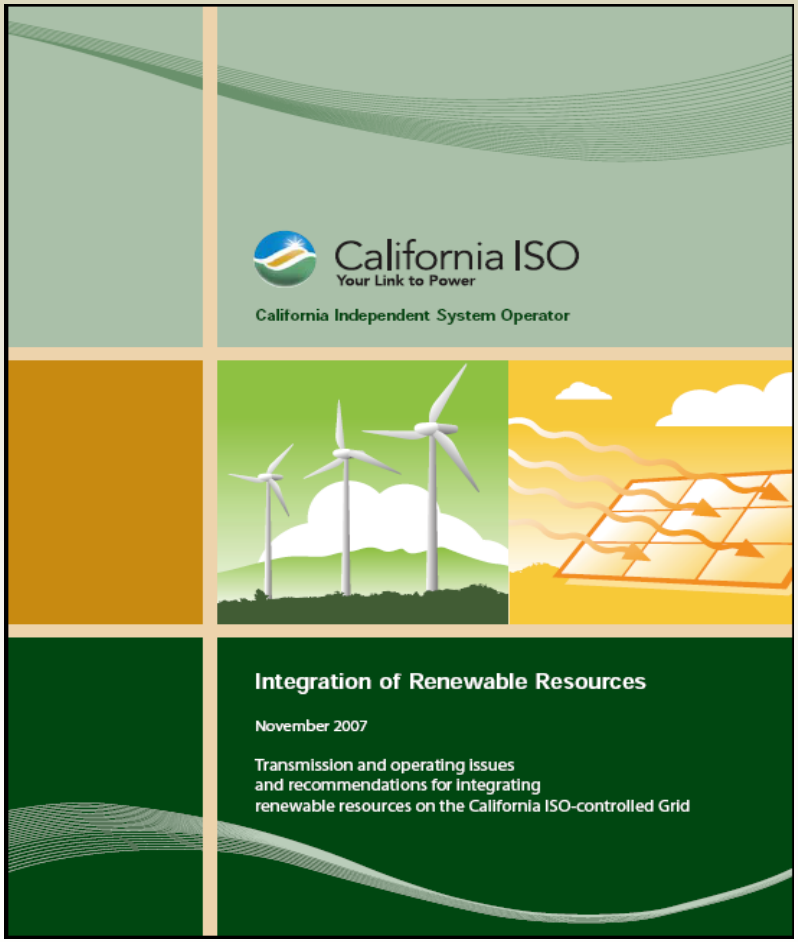
Operational issues and challenges

- Match generation to load
  - Better Day-ahead wind gen. forecasts to create more feasible schedules
  - Improved short term forecasts and better visibility to grid operators
- A/S procurement changes and Incremental Energy stack
  - Regulation - AGC
  - Operating Reserves (Spin, Non-spin, Frequency Response)
  - Incremental Energy dispatch (INC's and DEC's)
  - Ramping Requirements
  - Quick start capability
- Over generation mitigation
- Manage transmission congestion and loading
- Interchange scheduling of intermittent resources

Integration of Renewables Report published November 2007

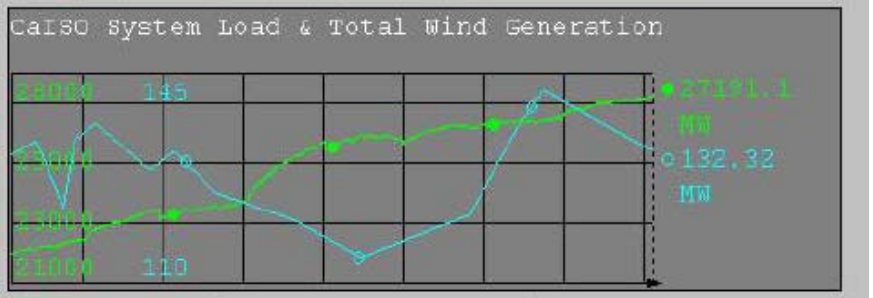
Key Report Topics

- Renewables transmission plans
  - Tehachapi transmission
  - Voltage & dynamic stability
- Forecasting wind & solar
- Operations integration
- Storage Technology
- Experience of others
  - National & International
- Conclusions & Recommendations
- Appendices
  - Detailed description of the study methodology



http://www.caiso.com/1ca5/1ca5a7a026270.pdf

California ISO Wind Generation



	Wind Speed m/s	Generation MW
Solano County	0 5.93 40	0
Altamont Pass	0 4.90 40	0 4.70 89
Tehachapi	0 0.00 40	0 0.40 60
Palm Springs	0 8.21 40	0 40.96 320.5
Kumeyaay	0 17.20 40	0

Total Load MW

Wind Gen MW

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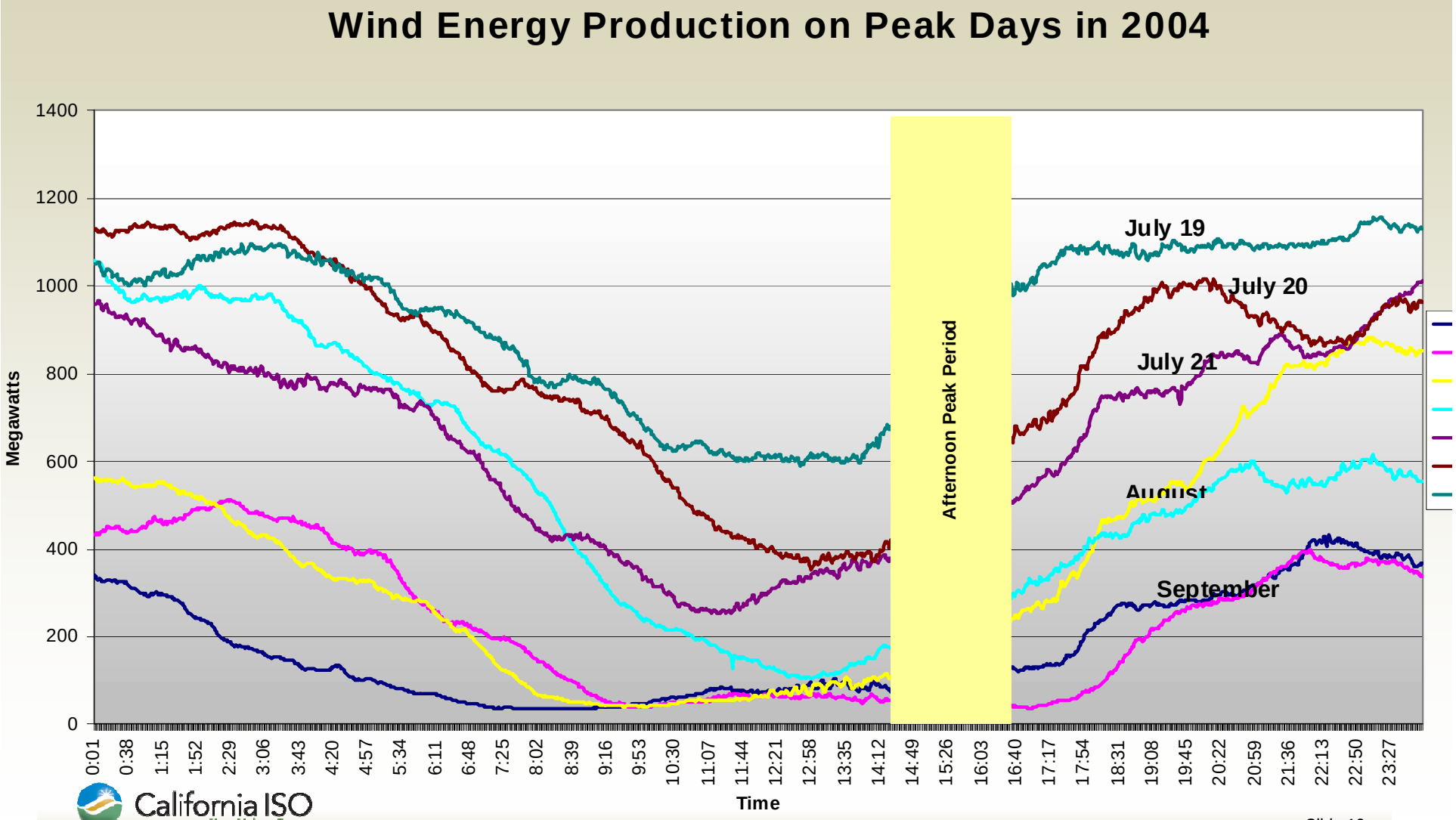
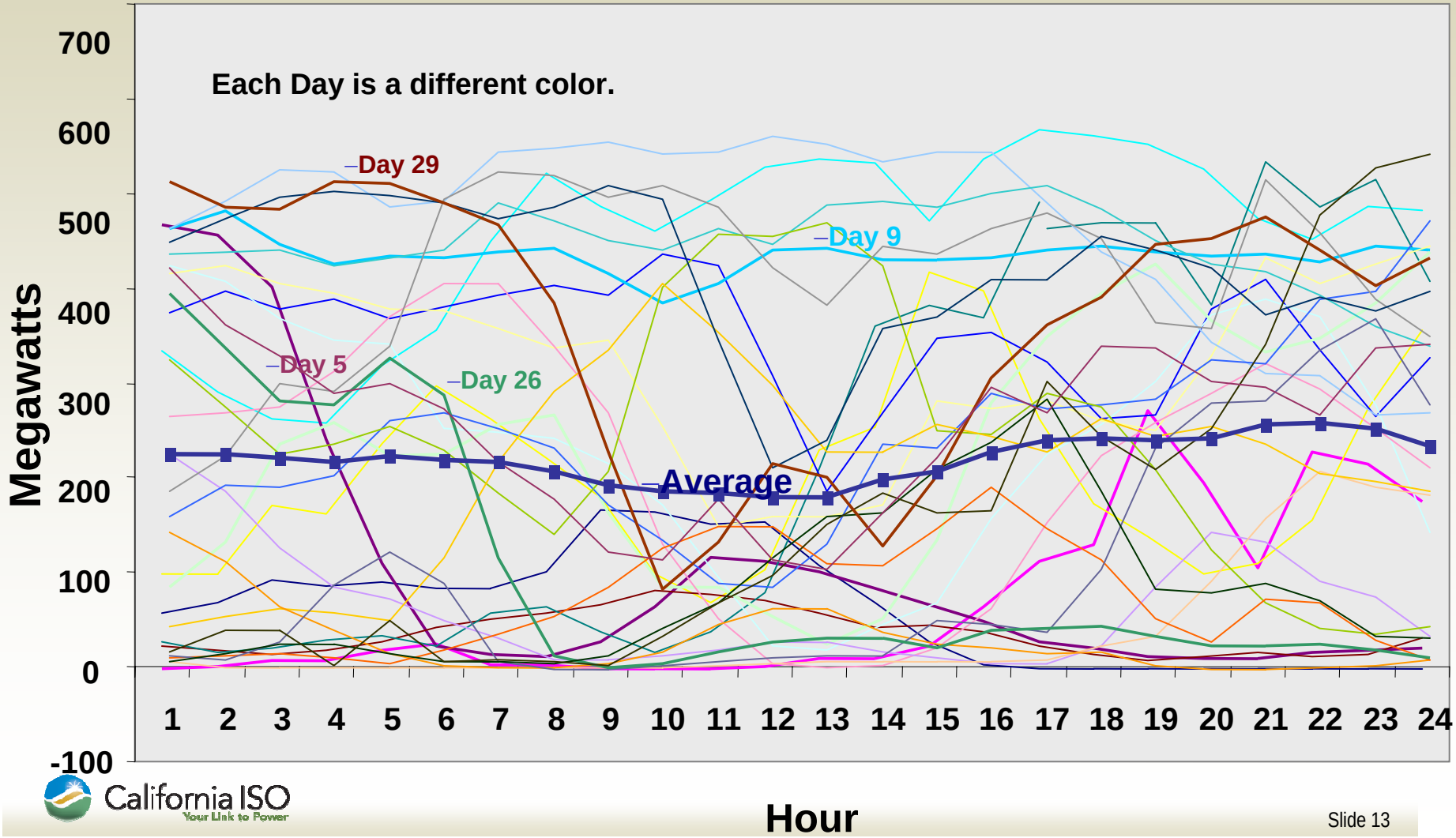
Capacity Value of wind to meet peak summer loads remains an issue



Wind Generation in April 2005

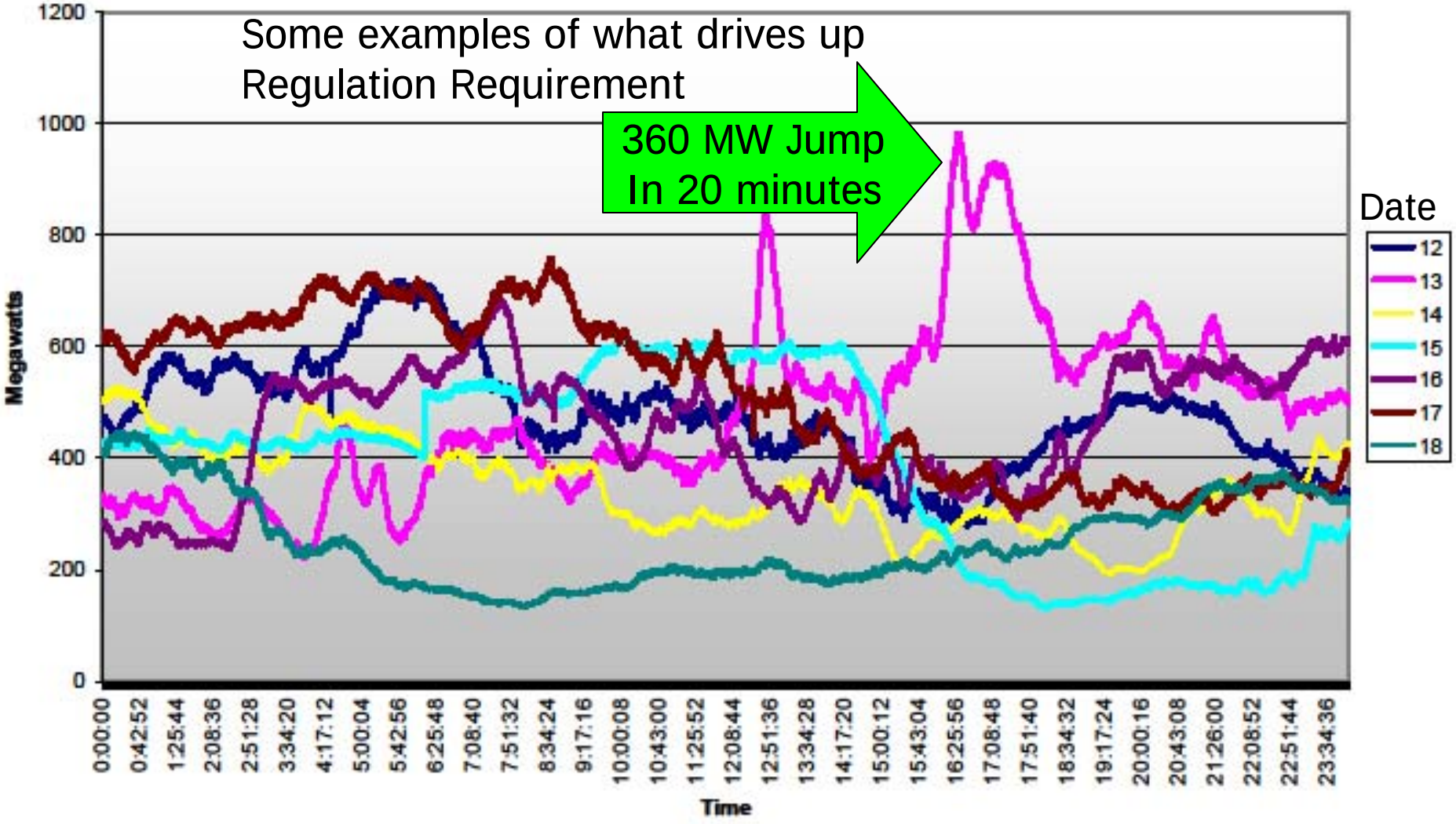
Could you predict the energy production for this wind park

either day-ahead or 5 hours in advance?

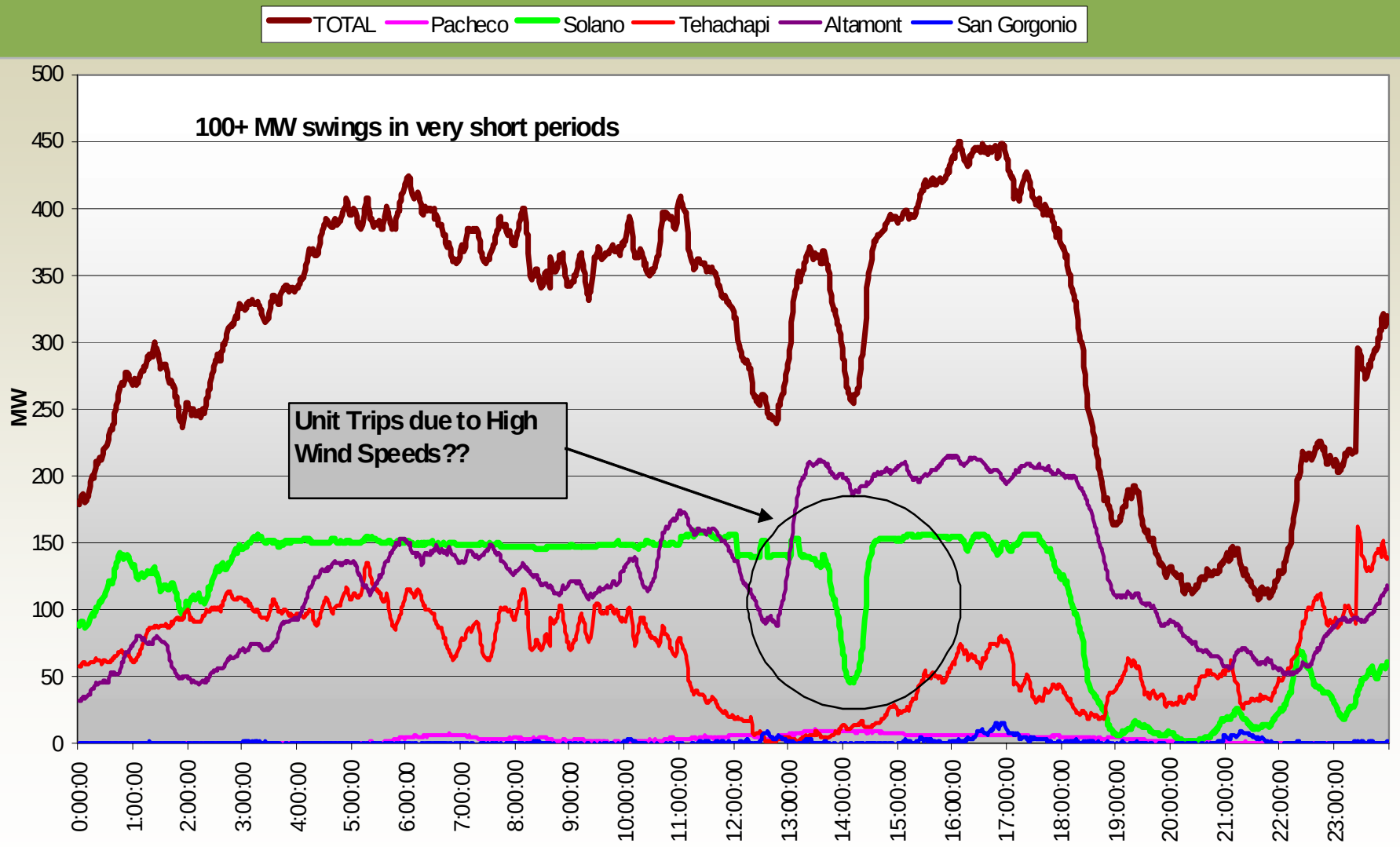


California ISO
Your Link to Power

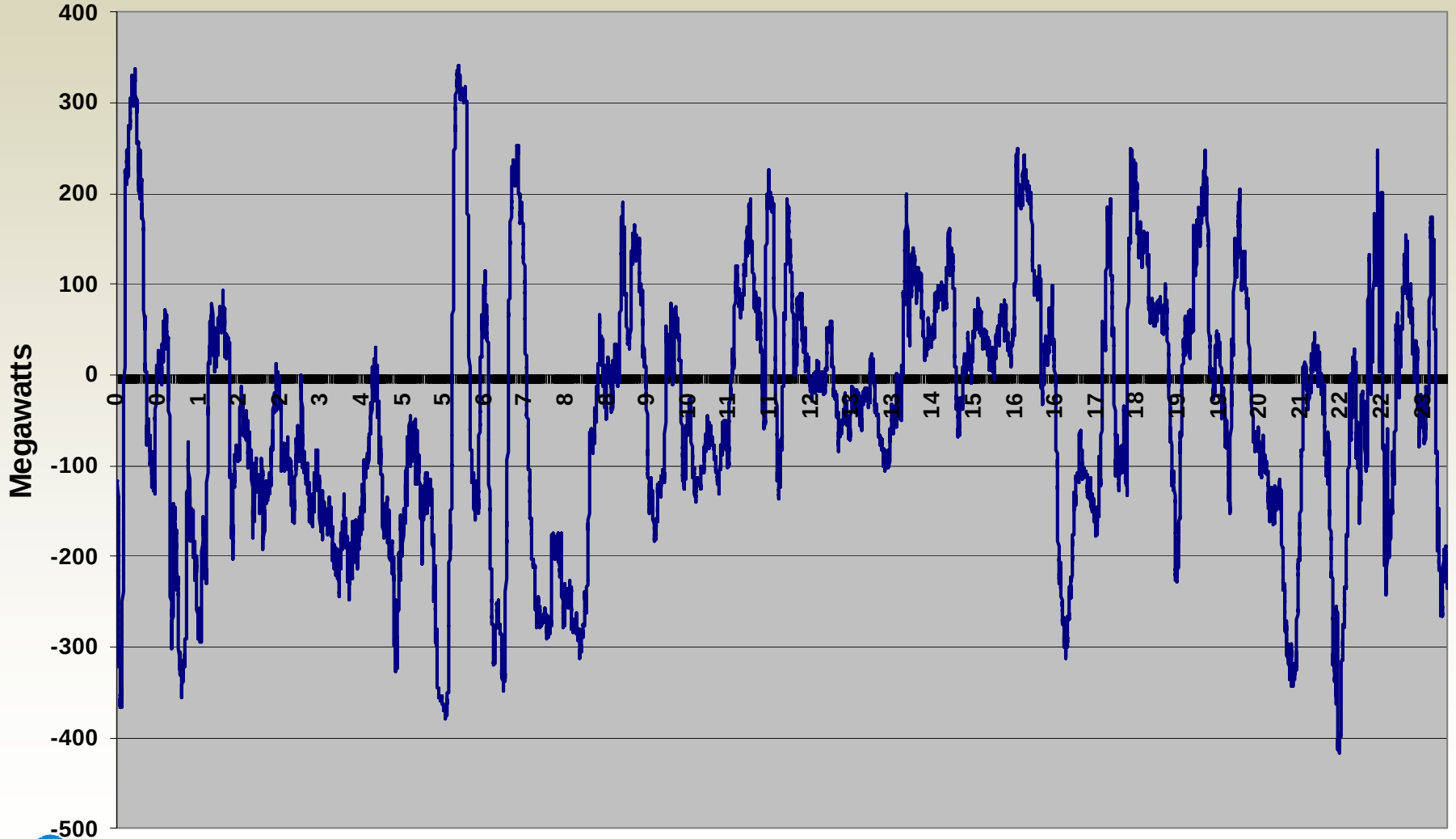
February 2009 Total Wind Generation
7 day plot of major Pacific Storm in California



January 7, 2005 California Wind Generation



Regulation required for 24 hour period

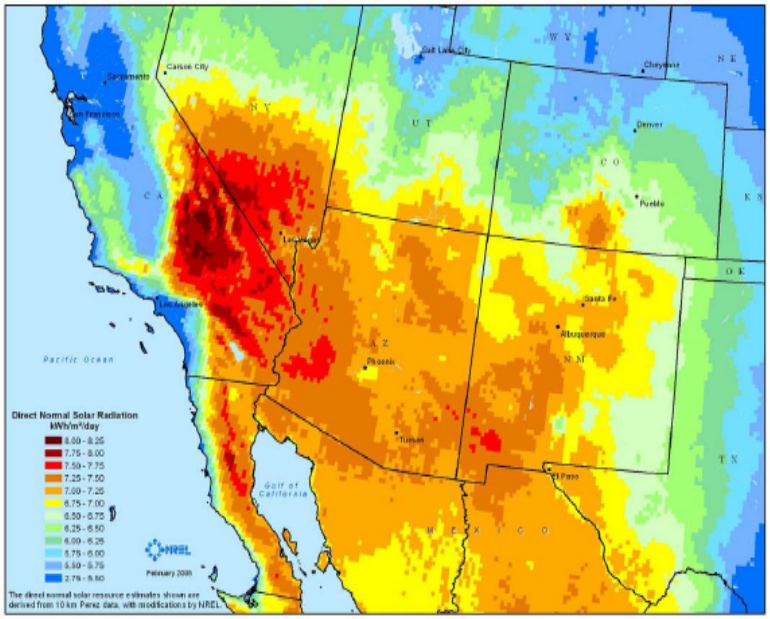


California ISO
Your Link to Power

Here comes the sun . . .

Southwestern area has solar energy potential equal to the total amount of energy from oil in Saudi Arabia

The Southwestern US has a solar resource that is better than the oil fields of the Middle East



California ISO
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PC Energy Production

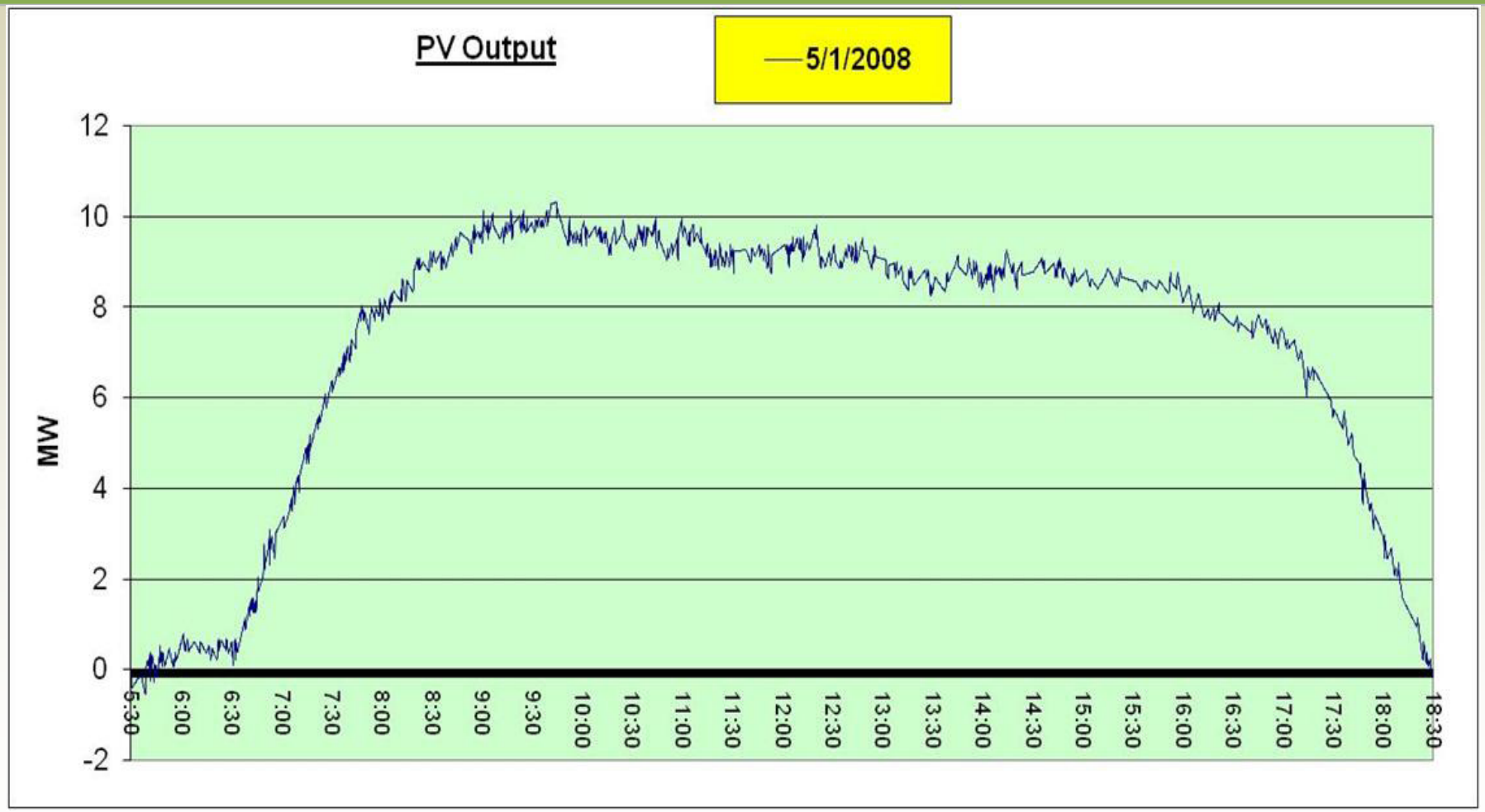


Figure 2.11: PV plant output on a sunny day (Sampling time 10 seconds)

Source: NERC Report - Accommodating High Levels of Variable Generation – March 2009

PV energy production

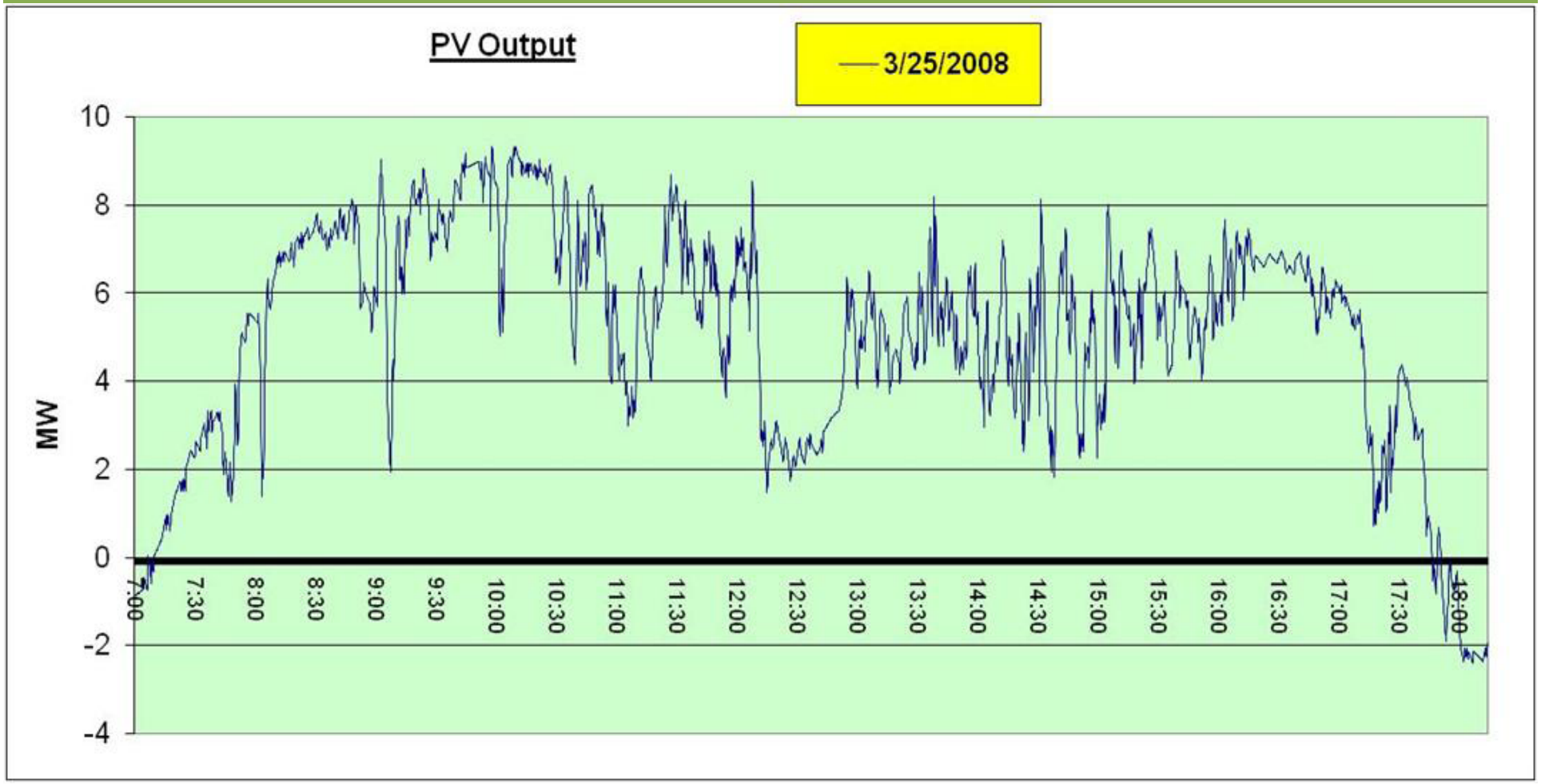


Figure 2.12: PV Plant output on a partly-cloudy day (Sampling time 10 seconds)

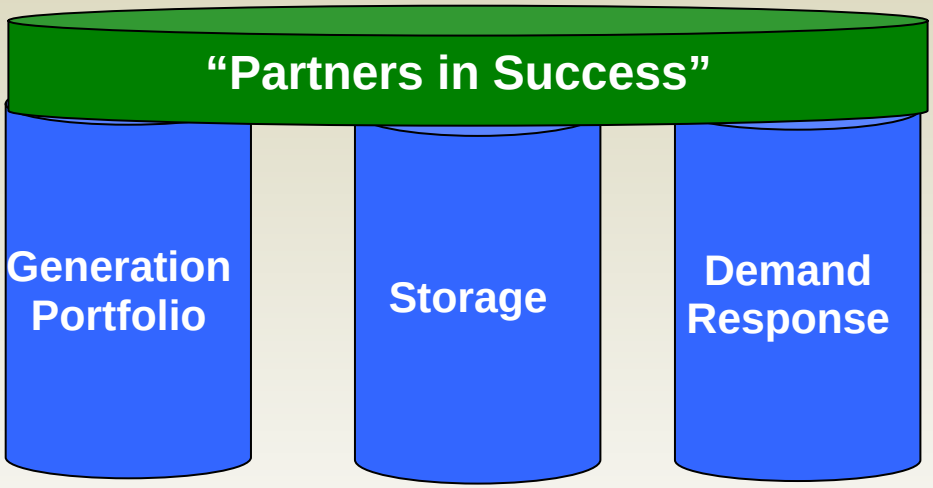
Source: NERC Report - Accommodating High Levels of Variable Generation – March 2009

Requirements for Integration of Renewables

Wind Generation

Solar Generation

Resources Required for Renewables Integration



Hydro Generation

- Quick Start Units
- Fast Ramping
- Wider Operating Range (lower P_{min})
- Regulation capability

- Shift Energy from off-peak to on-peak
- Mitigate Over Generation
- Voltage Support
- Regulation capability

- Price sensitive load
- Responsive to ISO dispatches
- Frequency Responsive
- Responsive to Wind Generation Production

CAISO Integration of Renewable Resources Program

Information about the CAISO program is available on web site

http://www.caiso.com/1c51/1c51c7946a480.html

Look in the CAISO web site **http://www.caiso.com** under the Operations section/ Stakeholder Initiatives and Current Initiatives/Integration of Renewable Resources

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